

Diabetic Ketoacidosis (DKA) Short Guideline

(consult the full guideline, prescribe treatment on the hourly IV insulin chart and adapt guidance to the clinical situation)

Diagnosis

Capillary glucose > 11.0 mmol/L and capillary ketones >3.0 mmol/L and venous pH < 7.3 or bicarbonate < 18 mmol/L

Initial Investigations

FBC, U+E, glucose, venous gases, blood culture, MSU, CXR, ECG, identify precipitant and treat appropriately

Fluids

1 litre 0.9% saline over 1 hour (on diagnosis)
 1 litre 0.9% saline over 2 hours (add KCl when U+E known)
 1 litre 0.9% saline over 2 hours
 1 litre 0.9% saline over 4 hours
 1 litre 0.9% saline over 4 hours
 1 litre 0.9% saline over 6 hours
 (This fluid regime is a guide & needs close review with response to treatment)

When glucose < 14.0 mmol/L reduce the rate of normal saline infusion by 50% and **ADD** 1L of 5% dextrose at a rate of 250ml/hour to this regime to continue via separate cannula.

However, if hypoglycaemia occurs or ketone levels increase using 5% dextrose then convert to 10% dextrose at 125ml/hour with saline at the initial rate, this needs good quality peripheral IV access or CVP line insertion.

Caution with fluids if: elderly, young 18-25 yrs (see cerebral oedema risk), CCF, renal failure, pregnancy or other co-morbidity

Potassium replacement
 (when U+E known, use of Saline premixed with potassium is recommended)

K ⁺ (mmol/L)	KCl to be added
>5.5	nil
3.5-5.4	40 mmol
<3.5	Senior review ? Additional KCl

Insulin

0.1 units /kg /hour (may need to estimate body weight), fixed rate insulin infusion of Actrapid 50units in 50mls 0.9% saline (eg if 70kg start at 7units/hour).

If known diabetic on basal bolus insulin, continue basal insulin Lantus or Levemir at usual dose (prescribe on insulin chart)

Monitoring-Refer to HDU or other appropriate setting (inc A&E, SAU, CDU, ITU or Diabetes ward) for monitoring.

Cardiac telemetry & O₂ saturation measurement

Strict fluid balance and 1 hourly urine output measurement (catheterize)

Measure blood ketones and glucose hourly

Blood ketones should fall 0.5 mmol/L per hour & blood glucose should fall by 3 mmol/L per hour

If not, increase insulin by 1 unit per hour

Monitor potassium 2 hourly aim to maintain potassium between 4-5mmol/L and avoid hypokalaemia

At 6 hours repeat venous pH & bicarbonate

Continue this treatment until complete resolution of acidosis (capillary ketones < 0.6 AND venous pH > 7.3).

Resolution has **usually** occurred by 12-24 hours.

Conversion to subcutaneous insulin. Occurs when acidosis has resolved and the patient is eating and drinking. Ideally this is done in consultation with diabetes specialist team (refer to main guideline). If acidosis has resolved but the patient is not yet eating continue IV fluids and change to a variable rate insulin infusion. Remember, **subcutaneous insulin should be administered 30 minutes before stopping the IV insulin.**

Severe DKA

One or more of these factors suggest severe DKA- enlist immediate senior input & critical care review

Blood ketones > 6.0

Systolic BP < 90mmHg

GCS < 12

Bicarbonate < 5.0

Pulse > 100 or < 60/min

Venous/arterial pH < 7.10

Oxygen saturation < 92%

Guideline for management of Diabetic Ketoacidosis (DKA) in adult patients

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Introduction

Diabetic ketoacidosis (DKA) is an altered metabolic state characterized by ketonaemia, acidosis and hyperglycaemia. It occurs due to absolute or relative insulin deficiency, with an increase in hormonal counter regulation. The hormonal imbalance increases hepatic gluconeogenesis and glycogenolysis resulting in hyperglycaemia with osmotic diuresis, which along with vomiting leads to water and electrolyte depletion. There is enhanced lipolysis & ketone body formation resulting in metabolic acidosis. Protein breakdown, renal impairment and acidosis can result in hyperkalaemia at presentation.

DKA is common with a mortality rate which is unacceptably high. The main causes of mortality in an adult with DKA include severe electrolyte abnormalities, adult respiratory distress syndrome (ARDS) and co-morbid states such as pneumonia, pancreatitis, acute myocardial infarction and cerebrovascular accidents. In children and adolescents (who may well be admitted on our adult wards) cerebral oedema remains the most common cause of mortality. DKA is a life threatening condition and patients must receive intensive nursing support especially during the early part of admission. Medical staff must assess the patient immediately and at least hourly during the early part of their hospital stay. **Indicators of severe DKA which need early senior intervention include, hypoxia, hypotension, tachycardia, reduced GCS or severe metabolic disturbances.**

Diagnosis (presence of each of the following)

- Diabetes or hyperglycaemia [blood glucose >11.0 mmol/l]
- Ketonaemia > 3.0 mmol/l
- Acidosis [venous pH <7.3 and/or HCO_3^- <18.0 mmol/l]

Investigations

Capillary and venous blood must be obtained.

Bedside tests and monitoring

Capillary glucose and ketones

Venous pH, bicarbonate and electrolytes via blood gas machines

Laboratory tests

FBC, U&E, LFT, glucose, amylase

*Blood cultures if indicated

Other investigations including CXR, ECG, MSU

*Infection may be present even if the temperature is low. Leucocytosis is common in DKA and does not always indicate infection

Assessment of Severity

One or more of the following indicators suggest severe DKA, patients should be transferred to HDU, have immediate senior input and critical care review.

- Blood ketones > 6.0 mmol/l
- Bicarbonate < 5.0 mmol/l
- pH < 7.10
- Hypokalaemia < 3.5 mmol/l on admission
- GCS < 12
- O_2 saturations < 92%
- BP < 90 mmHg
- Pulse rate >100/min⁻¹

Principles of treatment

- Rehydration and correction of electrolytes
- Correction of metabolic derangement
- Treatment of any precipitating cause

Fluid replacement

The initial priority in the management of DKA is appropriate fluid replacement followed by insulin infusion.

Adequate fluid replacement ensures

- restoration of circulatory volume (aim systolic BP>90mmHg)
- clearance of ketones
- correction of electrolyte imbalance

An illustration of fluid replacement is provided below. However, clinical judgment should always be used. Caution is needed in the elderly, pregnant patients, heart or renal failure, young adults aged 18-25 years (risk cerebral oedema) and other serious co-morbidities. In these cases all should be on level 2 HDU, fluids replaced cautiously and if necessary guided by CVP measurement.

Fluid	Volume
0.9% Saline	1000ml over 1 hour
0.9% Saline (add KCl once U+E known)	1000ml over 2 hours
0.9% Saline (add KCl as needed)	1000ml over 2 hours
0.9% Saline (add KCl as needed)	1000ml over 4 hours
0.9% Saline (add KCl as needed)	1000ml over 4 hours
0.9% Saline (add KCl as needed)	1000ml over 6 hours

Table 1. Saline replacement

Potassium replacement

Both hyperkalaemia and hypokalaemia are life threatening conditions and are common in DKA. Serum potassium is often high on admission due to reasons mentioned previously. This often falls precipitously after treatment with insulin. Hence regular monitoring is mandatory. No potassium is given with the first litre of fluid, while awaiting U&E results. Replace potassium after this accordingly. Saline premixed with potassium is recommended for this purpose.

Serum K ⁺ (mmol/l)	KCl to be added
>5.5	nil
3.5-5.4	40 mmol/l
<3.5	Senior review ?additional KCL

Table 2. Potassium replacement

Dextrose

Once glucose falls <14.0 mmol/L, commence 1000ml of dextrose 5% 4 hourly and reduce the rate of normal saline by 50%, which should also continue. The dextrose 5% infusion allows the insulin infusion to continue at a rate necessary to clear the ketosis & avoid hypoglycaemia. In cases of severe DKA or when DKA is slow to resolve, high rates of insulin infusion maybe required for a prolonged period. Occasionally, this can cause hypoglycaemia. In this setting dextrose 10% at 125ml/hour is recommended, this needs good quality peripheral access or insertion of a central venous line due to risk of extravasation injury. When dextrose 10% is used, saline should be infused at the rates shown in table 1, without the 50% reduction which is recommended when using dextrose 5%.

Insulin

Start a fixed rate intravenous insulin infusion via an infusion pump once intravenous fluids have been commenced. 50 units of human soluble insulin (Actrapid or Humulin S) made to 50 ml with 0.9% sodium chloride solution (if not already available as a ready made infusion).

Start the infusion at a fixed rate of 0.1 unit/kg/hr. Body weight may need to be estimated (eg weight 70kg = start 7 units of insulin/hour). This fixed rate infusion of insulin should continue until resolution of ketosis, it may need to be up titrated depending on the rate of resolution of DKA.

If the patient normally takes basal insulin (insulin Glargine or insulin Detemir) continue this at the usual dose and time.

Monitoring

Patients should be admitted to an area which has appropriate monitoring facilities. Appropriate areas include A&E, SAU, HDU, ITU or Diabetes wards. The decision will depend on severity of DKA and the level of monitoring required.

Patients should have hourly nursing observation, neurological observation including GCS and NEWS scoring, O₂ saturation monitoring, cardiac telemetry, fluid balance +/- urinary catheterization and CVP monitoring (depending on severity). IV fluid requires adequate venous access if there is difficulty obtaining adequate IV access liaise with the duty anesthetist for support (remember, IV cannulation of the foot should NOT be attempted). Point of care biochemical parameters should be monitored as follows.

- 1 hourly blood glucose and ketones
- 2 hourly potassium
- 6 hourly pH and bicarbonate

This cycle should be repeated until resolution of acidosis.

Aim to achieve:

- reduction in blood ketones by 0.5 mmol/l/hr
- reduction in glucose by 3 mmol/l/hr
- increase in HCO_3^- by 3 mmol/l/hr

The insulin infusion rate will need adjusting if the response to treatment is inadequate (ketones not falling by at least 0.5 mmol/L/hr; HCO_3^- not rising by 3 mmol/L/hr; blood glucose not falling by 3 mmol/L/hr). In this situation increase insulin infusion rate by 1 unit/hr increments hourly until the response is adequate. Ketoacidosis has usually resolved by between 12-24 hours after initiating treatment.

Bicarbonate & Phosphate

Adequate fluid and insulin therapy will resolve acidosis in DKA. Only give bicarbonate if pH < 7.0 and not responding to fluids and insulin within the hour. Use only 1.4% 500 ml sodium bicarbonate over 1 hour.

There is no evidence for the benefit of phosphate replacement. However, in the presence of respiratory or skeletal muscle weakness, phosphate measurement and replacement can be considered.

Resolution of DKA & conversion to subcutaneous insulin.

- blood ketones consistently less than 0.6 mmol/L
- venous pH over 7.3
- Do not use HCO_3^- or urine ketones as surrogate markers of resolution

Once the patient is able to eat and drink, blood ketones are <0.6 mmol/l and venous pH >7.3 the patient can convert to subcutaneous insulin. This is ideally managed by the diabetes team. Generally, previous regimes are re-started. Provided basal insulin was continued, the IV insulin can be discontinued 30 minutes after the first dose of short acting insulin given with a meal. If this is a new diagnosis of type 1 diabetes or basal insulin was not continued while on IV insulin, then a basal insulin (eg Lantus or Levemir) should also be administered 30mins before the IV insulin infusion is stopped. If ketoacidosis has resolved but patient is not yet eating, then they can be converted to variable rate insulin infusion with IV fluids as per protocol. In newly diagnosed patients, it is essential that they are seen by the diabetes team for appropriate insulin initiation, re-education and to facilitate follow-up.

Potential complications

- **Hypotension**

If SBP <90 mmHg then give a rapid bolus of 500ml of normal Saline this can be repeated if SBP fails to be >90mmHg while awaiting senior input. These patients need critical care input.

- **Hyperkalaemia & Hypokalaemia**

Hyperkalaemia is seen with acute renal failure and the metabolic disturbances of DKA. However, it will almost always fall with hydration and insulin therapy. If K^+ is below 5.5mmol/l & passing urine 40mmol/l KCl is recommended. If K^+ falls below 3.5mmol/l more concentrated potassium replacement maybe needed and should be done according to local policy. Aim to maintain potassium concentration between 4-5 mmol/l.

- **Hypoglycaemia**

Hypoglycaemia can develop rapidly as DKA is corrected. This can be associated with rebound ketosis, prolonged DKA, cardiac arrhythmia, brain injury or death. Once glucose falls below 14.0mmol/l 1000ml Dextrose 5% should be commenced to prevent hypoglycaemia. If hypoglycaemia occurs despite Dextrose 5% then consider use of Dextrose 10%, this may require central venous access.

- **Cerebral oedema**

This is a relatively uncommon complication in adults, the exact cause being unknown. It is most commonly seen in children or adolescents with severe acidosis. Indicators include headache, slow pulse, increasing BP, altered mental status. Effective treatments such as hypertonic saline or mannitol must be given early and there should be liaison with critical care teams. Fluid management should be calculated according to body weight and degree of dehydration in patients less than 18 years of age. It is also appropriate to apply these recommendations in young adult patients who are of small stature. There is a trust protocol available for the management of DKA in paediatric patients.

This guideline is based on the recommendations of the Joint British Diabetes Societies Inpatient Care group. The management of Diabetic Ketoacidosis in Adults 2010. Available at www.diabetes.nhs.uk However, this is a guideline and does not replace clinical judgment.

References

The management of Diabetic Ketoacidosis in adults 2010. Joint British Diabetes Societies Inpatient Care group. Available at www.diabetes.nhs.uk

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